Chapter 9

Introduction to Networks

9.1 Uses of a network

Networks are used in many situations. We can see networks in places like offices, airports and factories. In fact we use networks in many situations of our day to day life. For example the Internet, we use to send e-mail and download information is an example of a network. Some uses of networks are described below.

9.1.1 Simultaneous data access.

There are computers called database servers which are used to store data because they are designed to do data management. By storing shared data in a database server, computers can have access to the data at the same time through a network (figure 9.1). Further, there are program versions called network versions which can be stored in a server and shared by the computers of a network. This avoids duplicating programs in each machine (figure 9.2).

9.1.2 Share peripheral devices.

Another use is to share peripheral devices such as laser printers which are expensive. In this case, a software called the network operating system manages the use of the shared peripheral device (figure 9.3). For example a network operating system will not allow a printer to be used by a computer in the network if it is used by another computer in the network at the same time. It would queue the print jobs in a ”first come first served” basis.

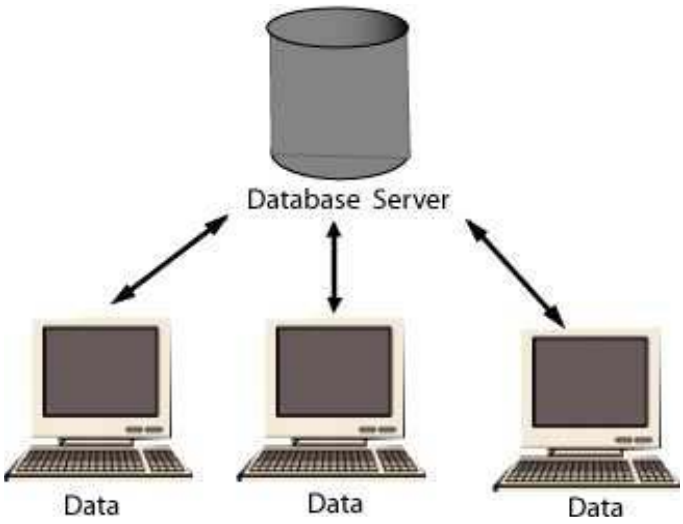


Figure 9.1: Sharing data

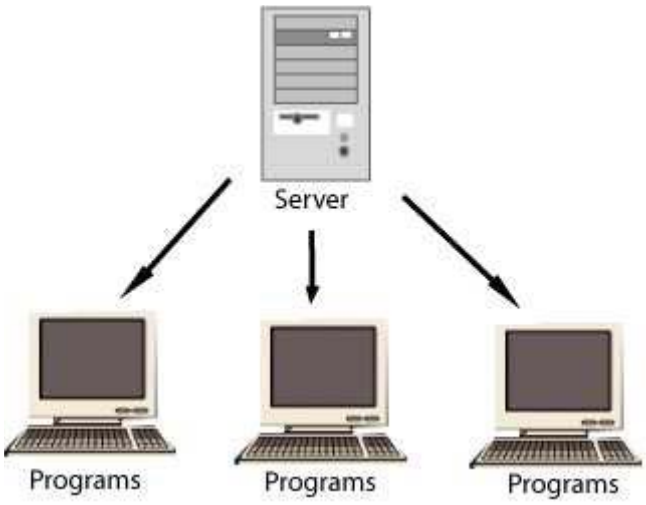


Figure 9.2: Sharing network versions of programs

9.1.3 Communication.

Networks link computers together. As a result networks provide a means to communicate between machines. For example we use networks when we send e-mails (figure 9.4) and download information from the web. Networks are also used for real time communication like, chatting (text, voice and video), Internet Telephony and video conferencing.

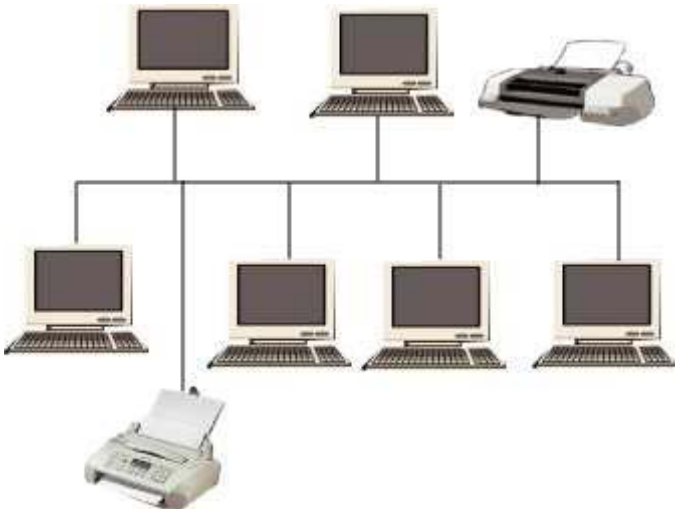


Figure 9.3: Use of networks to share peripheral devices

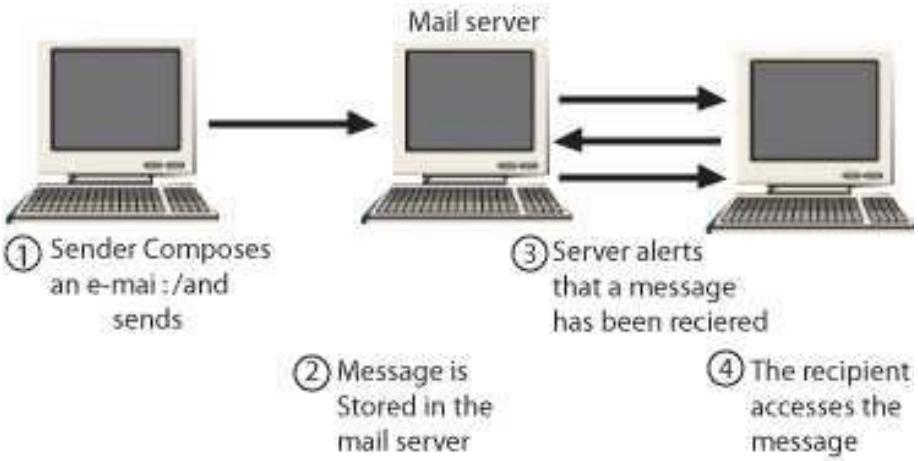


Figure 9.4: Communication through e-mail

9.1.4 Backup data from one computer to another.

A network can be used to send backups of data from a computer in the network to a database server which is attached to the network. The software which manages and coordinates a network called the network operating system usually backups data time to time (figure 9.5). Backing up of data is important to avoid loss of important and critical data due to physical damage to the computer data or the corruption of computer data.

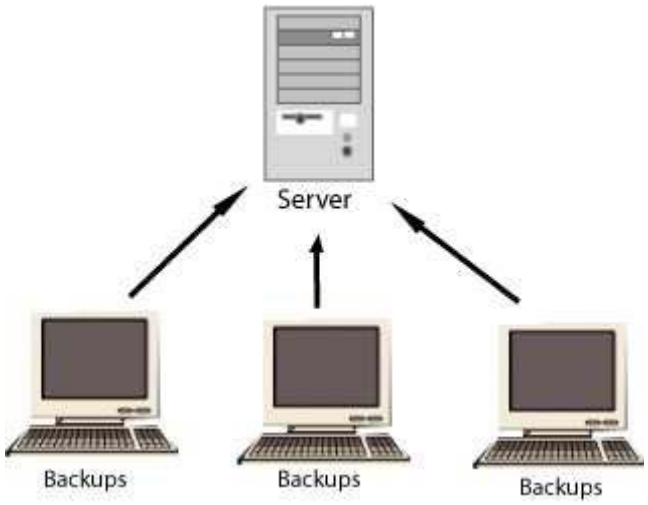


Figure 9.5: Use of a network to backup data

9.2 Data communication media

Data communication media refers to the means through which communication takes place in a network. For example telephone wire is one of the mediums use din networks and we use it when we usually get connected to the Internet from home.

These media have their own advantages and disadvantages. When choosing a media we have to consider factors like cost and data transmission rate (amount of data transferred during a unit period of time).

Two types of media can be identified. They are wired media and wireless media. These are discussed in sections 9.2.1 and 9.2.2. See section 9.5 for some of the applications which use these media.

We measure data transmission speed using bits per second (bps). For example if 100 bits are transmitted in a second we say the transmission speed is 100 bps. If 1000 bits are transmitted we say the speed is 1Kbps. Similarly 1 Mbps is 1000 Kbps and 1 Gbps is 1000 Mbps.

9.2.1 Wired media

Wired media are different types of wires used to transmit data. Examples are twisted pair, coaxial and fibre-optic cables.

9.2.1.1 Twisted-pair cable

A Twisted-pair cable consists of usually 4 pairs of twisted wires (figure 9.6). Each such pair consists of two insulated twisted copper wires. These cables are commonly used in Local Area Networks (LANs) and support data transmission rates up to 1Gbps.

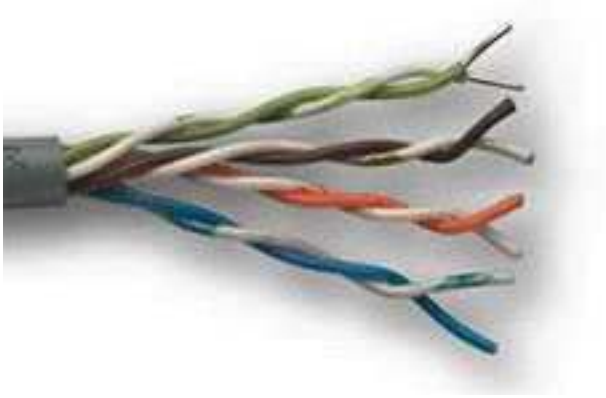


Figure 9.6: Twisted-pair cable

9.2.1.2 Coaxial cable

A coaxial cable consists of an inner conductor wire surrounded with 3 layers. These 3 layers consist of an inner insulating material, a middle woven metal grid and an outer plastic coating (figure 9.7). Coaxial cables can support data transmission speeds of up to 10 Mbps.

Figure 9.7: Coaxial cable

9.2.1.3 Fiber-optic cable

The core of a fibre-optic cable contains dozens or even hundreds of very thin glass/plastic strands. Data transmission happens through these strands (optical fibres) which use light as the medium to transmit data (figure 9.8). Fibre-optic cables are capable of data transmissions speeds of approximately 100Gbps. Both Twisted-pair cables and Coaxial cables carry electrical signals and require no special device to convert the signals. But since fiber-optic cables use light it needs a device at either end to convert electric signals to light and vise versa.

Figure 9.8: Fibre-optic cable

9.2.2 Wireless media

Wireless media use air or space to transmit data. Radio waves and light waves are used by many wireless media. Some of the wireless media are discussed below.

9.2.2.1 Microwave transmission

Microwave transmission uses high frequency radio waves. To communicate using microwave, signals are sent to a transmitter which amplifies them and transmits it through the aid of an antenna. Several such transmitters/ retransmitters and antennas may be used before the signal reaches the destination antenna and receiver (figure 9.9). These transmitters/ retransmitters are placed approximately 50 to 100 kilometers apart and must be visible to each other (line of sight). For example, microwave transmission can be used to connect branches of a bank in Colombo, Nugegoda and Gampaha.

A communication satellite is a kind of microwave transmitter/receiver (trans- receiver) placed in space. A satellite amplifies signals from the transmitter stations on earth and then retransmits them to the receiver stations on earth (figure 9.10).

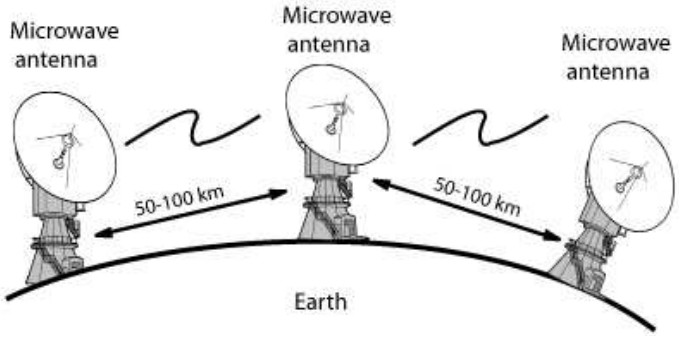


Figure 9.9: Microwave transmission

The advantage of using satellite over earth based stations is that signals can be transmitted with less number of hops (1 hop is the connection between two adjacent stations) since there are no geographical obstacles that obstruct line of sight.

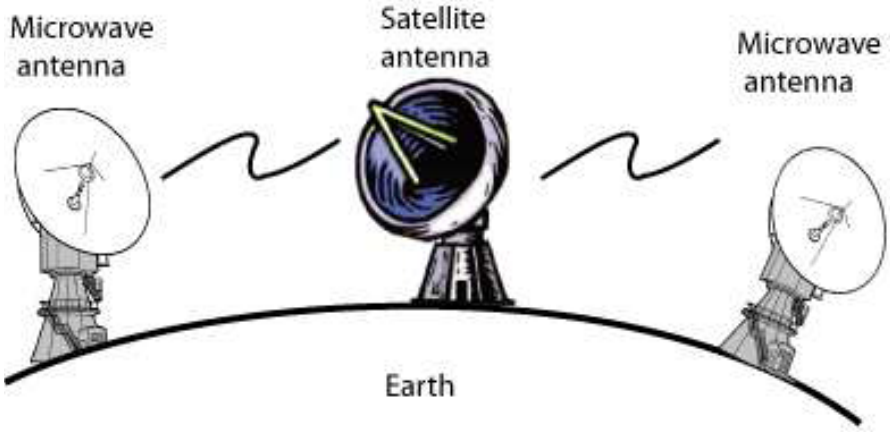
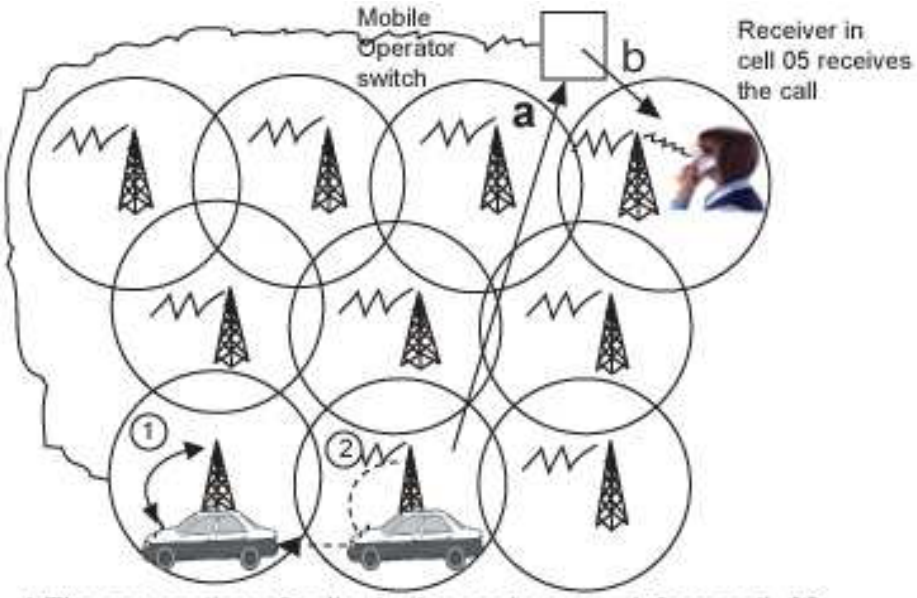


Figure 9.10: Satellite transmission

9.2.2.2 Cellular transmission

Cellular transmission uses radio signals. It is the one which is used by mo- bile/cellular phone technology. In cellular transmission a particular geographical area is divided into cells each having a trans-receiver antenna. Mobile phones inside a particular cell transmit and receive data through the antenna of the cell. As the user moves from one cell to another, (for example when driving) the phone connection is passed from the current cell antenna to the next cell antenna (figure 9.11).



1 The connection of caller in the car is passed form cell 02 to cell 01

2 The caller in the car dials a call
  a The call is connected to the mobile operator switch
  b The call is transformed to the tower that the called persons cell is in (3)

3 The callers mobile and called mobile are connected

Figure 9.11: An example of cellular transmission

9.2.2.3 Infrared transmission

Infrared waves are a form of light waves used to transmit signals across short distances. For example infrared is used to transmit signals from a remote controller to a television. It also can be used to connect devices like computers, cellular phones, PDAs, fax machines and printers to form wireless Personal Area Networks (PANs) [see section 9.4.1].

9.3 Devices used to link computers

These are the devices used to connect computers together in order to form a network. Some of them are described in sections 9.3.1 to 9.3.5.

9.3.1 Network Interface Card (NIC)

A computer is connected to a network through a hardware device called a network interface card (figure 9.12). A NIC controls the data flow to and from the network. It fits in to one of the expansion slots of the main circuit board of a computer and contains a port where the network cable can be attached (RJ45, Coaxial adapter, Optical connector). The control of the NIC is governed by the network software and the operating system.

Figure 9.12: A Network Interface Card

9.3.2 Modem

Telephone networks use wave like signals which are called analog signals .But the data we generate using a computer are not analog. They are digital (figure 9.13). So we use a modem (figure 9.14) to transform the digital signals to analog signals (Modulation) and to convert the analog signals received over the telephone line to digital signals (De-Modulation). Since the it does Modulation and Demodulation we refer to it as the Mo-Dem or Modem. For example, we use a modem to get connected to the Internet via a telephone network (figure 9.15).

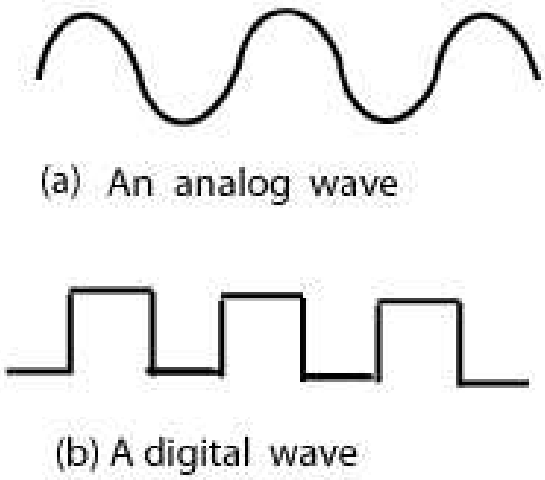


Figure 9.13: Analog and digital waves

Figure 9.14: A Modem

9.3.3 Hubs

A hub is a central connection point to all the nodes of a network (figure 9.16). A hub merely broadcasts the data it receives from one node to all the nodes attached to it the hub (figure 9.17).

9.3.4 Bridges

Another term for a bridge is ‘network switch’ (figure 9.18). A bridge is a device used to connect segments of a network which has the same IP address range. An IP address is an identifier given to a computer or device on the network to

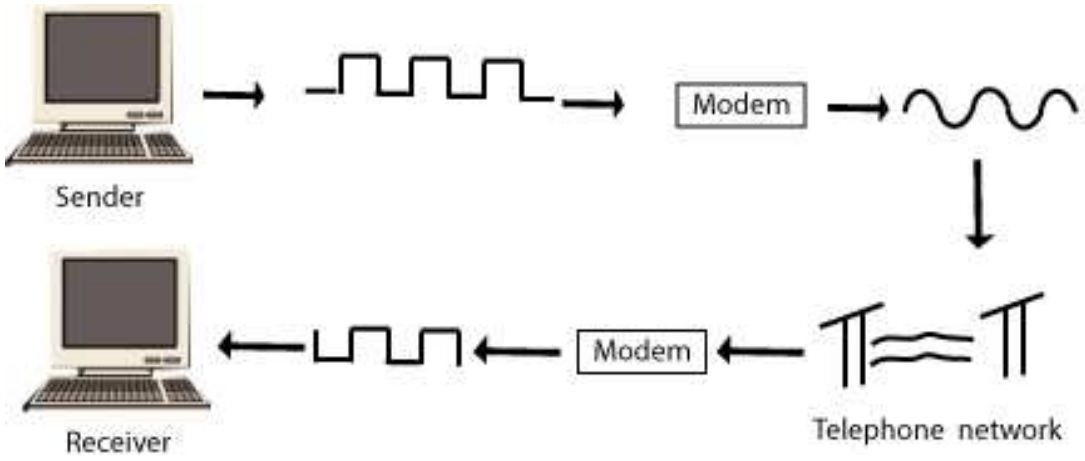


Figure 9.15: How a Modem Works

Figure 9.16: A Hub

Uniquely identify it. For example a bridge can be used to connect the LANs of different department of the same building together (figure 9.19).

9.3.5 Routers

A router connects two or more networks having different IP addresses (figure 9.20). When data transmission happens from one network to the other through a router, it chooses the best path for the incoming data to be sent to the receiver (figure ??). This choice is influenced by the levels of data traffic in different routes. The path from the sender to the receiver may also change from time to time as the traffic varies on the network links, and some existing connections may break and new ones may form.

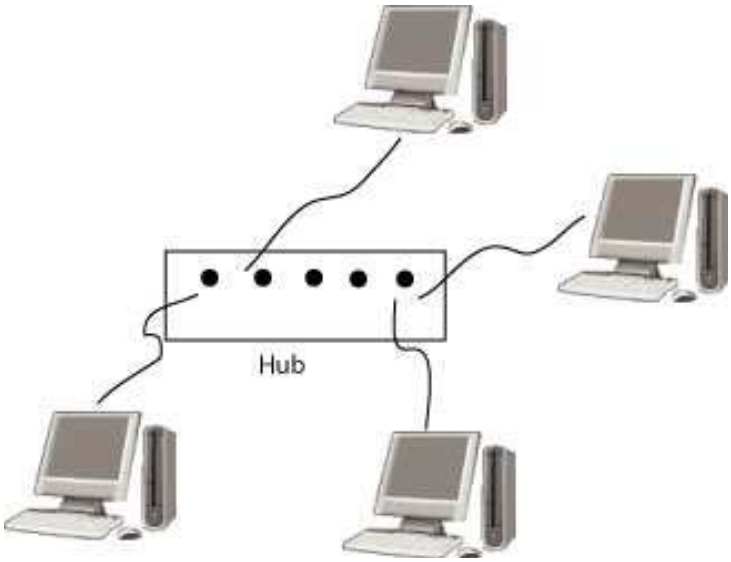


Figure 9.17: How computers are connected to a Hub

Figure 9.18: A Bridge

9.3.6 Gateways

We use a gateway to connect networks which use different standards (figure 9.22) [see section 9.5]. For example gateways are used to connect a cellular network to the Internet ((figure 9.23).

9.4 Different Types of Networks

The following categorization is based mainly on the geographical span (physical distance) of the computers and other devices which are attached to a network. We call these computers and devices, nodes.

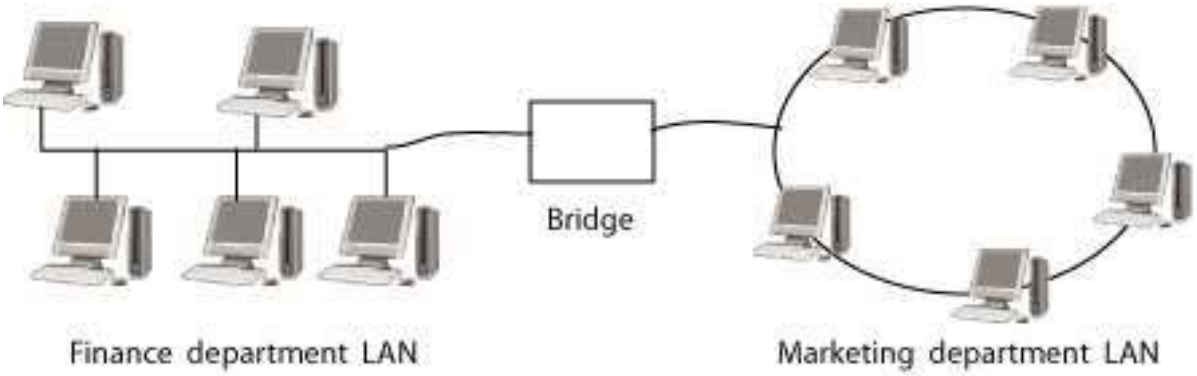


Figure 9.19: How LANs of a building are connected using a Bridge

Figure 9.20: A Router

9.4.1 Personal Area Networks (PANs)

A PAN is a network of devices in a range of about 10 meters. Imagine a laptop, digital camera and a portable printer connected wireless where images are down- loaded from the digital camera to the laptop and printed through the printer. Another example would be a blue-tooth hands-free device connected to the mo- bile phone, PDA or Notebook computer (figure 9.24).

9.4.2 Local Area Networks (LANs)

A LAN refers to a network in a small area like an office building (figure 9.25). Computers connected with each other in a computer lab or a small hospital is an example for a LAN. There are two type of LANs called client-server LANs and peer-to-peer LANs.

In a client-server LAN, powerful computers called servers are attached to the network.

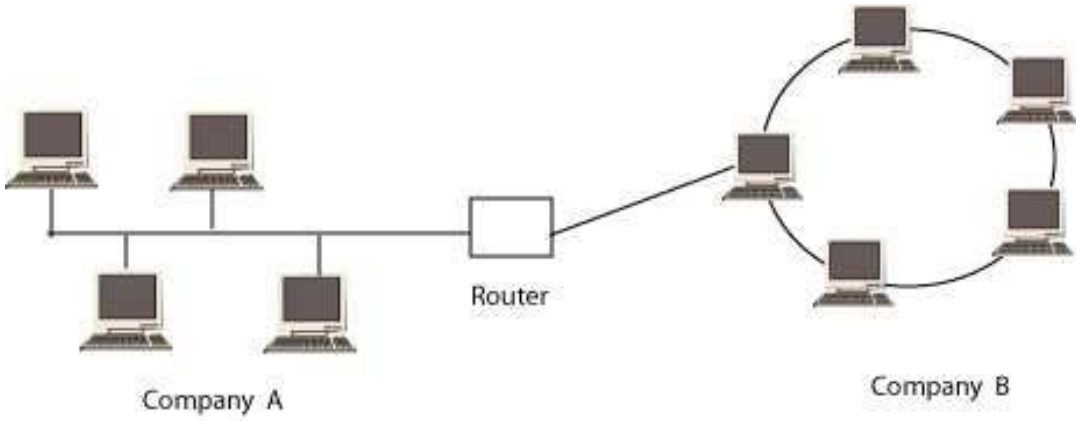


Figure 9.21: How Routers connect networks

Figure 9.22: A Gateway

These computers processor and memory intense work like communicating with the outside world and database handling. Clients are computers that access the servers to obtain some service. In a peer-to-peer LAN all the computers have the same privileges and each can access the others for data and services.

Computers in a LAN can be arranged in many different ways. We call these arrangements, topologies. Figure 9.33 shows some of the widely seen LAN topologies.

When speaking of LANs it is important to mention about intranets. An intranet is a LAN inside a company which is based on internet technology. Because it is based on the internet technology an intranet can be used to do things like send e-mails, share information and perform day to day business operations within an organization. It uses the TCP/IP protocols.

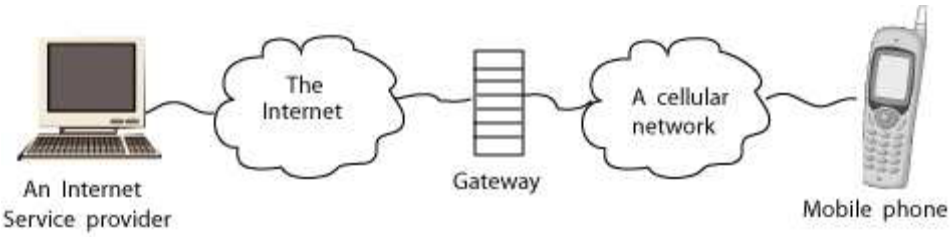


Figure 9.23: A Gateway between a cellular network and the Internet

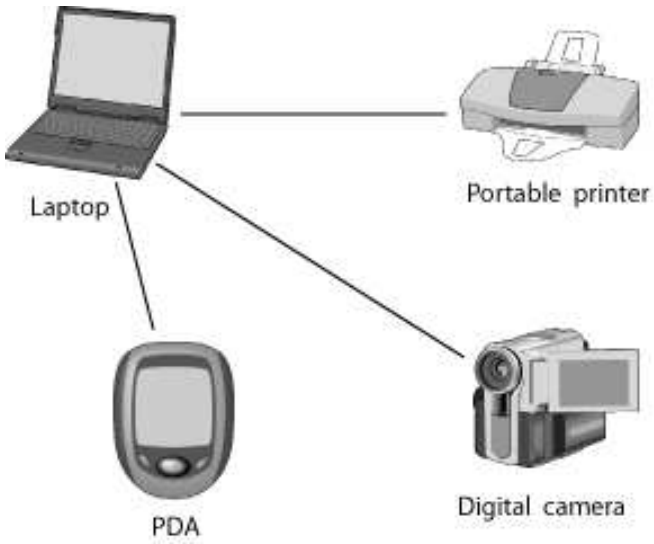


Figure 9.24: A Personal Area Network (PAN)

On the other hand we use the term ‘extranet’ to refer to network links which link a company’s intranet with the intranets of its business partners, suppliers and customers.

It is also important to know the term ‘Campus Area Network (CAN)’. A CAN refers to large scale LAN which connects computers of several buildings like in a campus.

9.4.3 Wide Area Networks (WANs)

AWAN refers to a network that spans a large area like several cities. For example a Bank network which has LANs in several cities of Sri Lanka is an example for a WAN (figure 9.27).

WANs usually use public communication infrastructure such as the telephone network to save cost of developing privately owned infrastructure.

Sometimes the term ‘Metropolitan Area Network (MAN)’ is used to refer to networks that span a city size area. As such MAN is larger than a LAN but smaller than a WAN. A network connecting all the LANs of government offices

Figure 9.25: A Local Area Network (LAN)

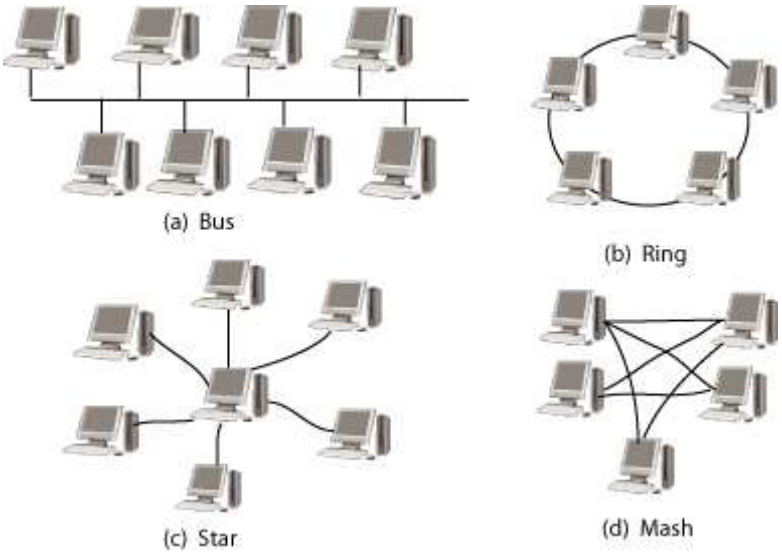


Figure 9.26: LAN topologies

Within the Colombo city is an example of a MAN.

9.5 Data communication standards

Several data communication standards exist. They specify things like the medium of transmission and the technology. Standards exist for wired media and wireless media.

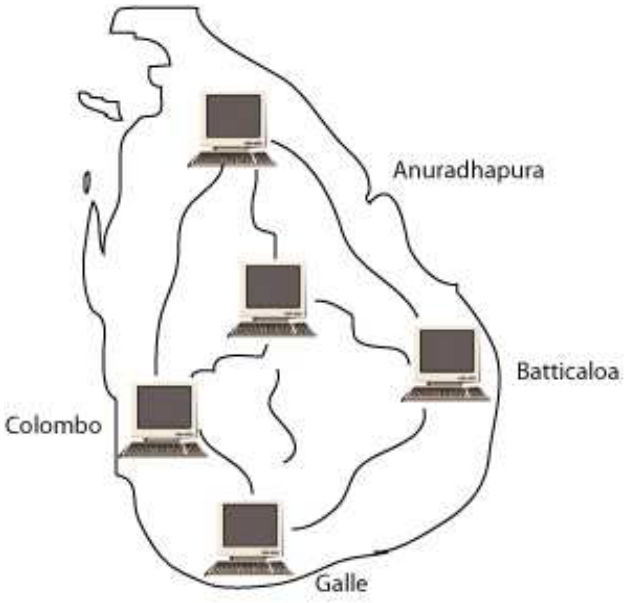


Figure 9.27: Example of a Wide Area Network (WAN)

9.5.1 ISDN (Integrated Services Digital Network)

ISDN is a data communication standard defined to be used with ordinary telephone lines. ISDN is designed to provide multiple digital services like Internet access, voice and video over the ordinary telephone line (figure 9.28). It provides faster transmission using a technique called multiplexing. Multiplexing is a technique which packs several input signals into one fast output signal. In order to use ISDN both ends of the connection must have an ISDN adaptor which does multiplexing and de-multiplexing (the opposite of the multiplexing process) at the sender's and receiver's ends respectively. ISDN will result in faster down- loads and clearer audio and video transmissions compared to normal telephone connections.

9.5.2 ADSL (Asymmetric Digital Subscriber Line)

ADSL uses ordinary telephone lines to deliver higher data rates. In order to use ADSL you need to have an ADSL modem and the ADSL service must have to be offered by the service provider. The downlink data rate in an ADSL is much higher than the uplink data rate. As such ADSL is ideal for Internet access because many users download data more than they upload (figure 9.29).

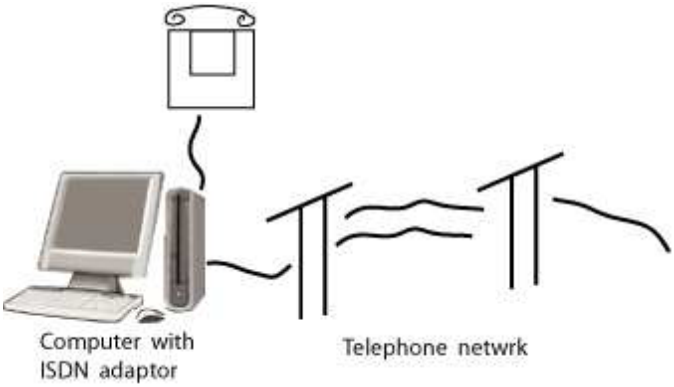


Figure 9.28: ISDN

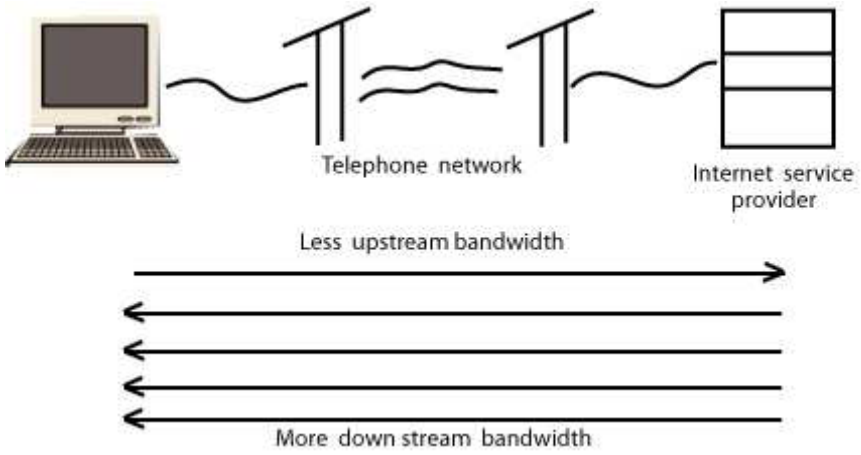


Figure 9.29: ADSL

9.5.3 Ethernet

Ethernet is the most commonly used LAN standard. In an Ethernet LAN a node transmits data after sensing that the network is not used by any of the other nodes (figure 9.30). In fact it keeps on sensing and retransmits if it senses the data it sent earlier had collided with data from another machine.

The original Ethernet implementations were called 10Base-2 and 10Base-5. These Ethernet used coaxial cables. The most popular Ethernet standard is called 10Base-T. It is based on the star topology and uses twisted-pair cables. It supported speeds up to 10Mbps.

Several standards like Fast Ethernet and Gigabit Ethernet have extended the basic Ethernet standard resulting in higher data rates. For example the Fast Ethernet standard (100Base-T) supports up to 100Mbps and the Gigabit Ether- net standard (1000Base-T) supports up to 1Gbps. These are suitable for high bandwidth applications such as graphics and video. For example if workstations in a movie production house need to send video clips between them for editing, Gigabit Ethernet should be the best option.

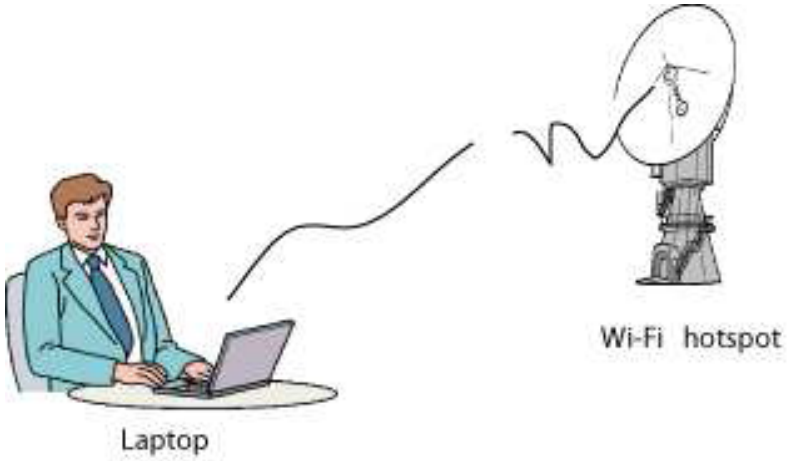


Figure 9.30: Ethernet

9.5.4 Wi-Fi

Wi-Fi is a standard for wireless LANs. The Wi-Fi access point (a trans-receiver) has a normal range of about 100m. The area covered by one of these access points is refered to as a ”Wi-Fi Hot Spot”. If a computer or device which supports Wi-Fi and is in a Wi-Fi hot spot can connect to these access points network (figure 9.31). Wi-Fi hot spots are located in public places like airports, restaurants and roads. For example the Colombo airport has Wi-Fi hotspots through which you can access the Internet if you have a Wi-Fi enabled laptop, while waiting for the flight.

Wi-Fi has 3 common standards. The IEEE 802.11a has a bandwidth of 54Mbps and IEEE 802.11b and IEEE 802.11g have a bandwidth 11Mbps.

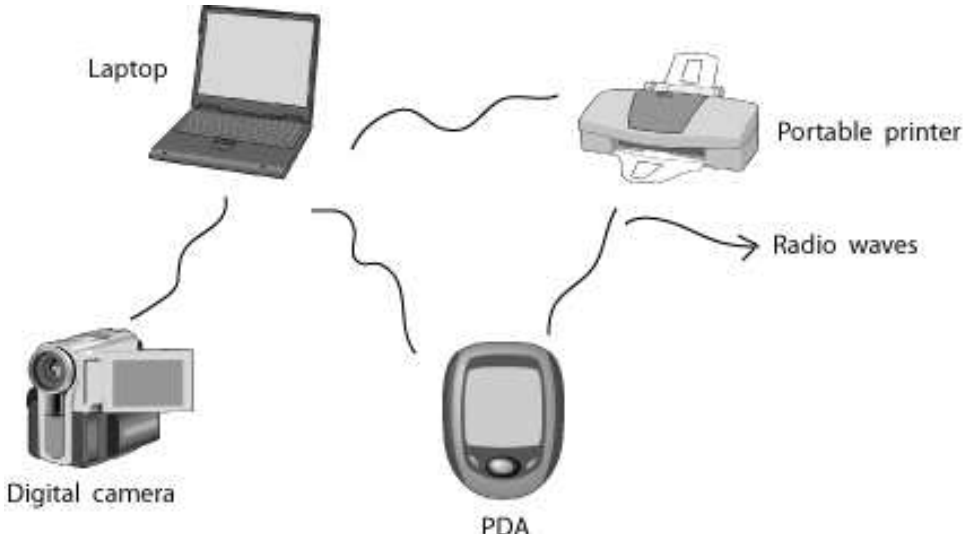


Figure 9.31: Wi-Fi

Figure 9.32: Wi-Fi Symbol

9.5.5 Wi-Max

The term ‘Wi-Max’ has been derived from ‘Worldwide Interoperability for Microwave Access’. It is a standard which has been built to support wireless MANs.

In a wireless MAN you can find several base stations running across a city with subscribers attached to each base station as shown in figure 9.31. These sub- scribers may be home computers, company networks or even Wi-Fi access points.
The accessible range for a subscriber from a tower is about 50 kilometers. Wi- Max supports a data transmission rate of 70 Mbps. It is a low cost substitute for wired connections because it does not need a costly physical infrastructure like wired data transmission (figure 9.33). For example Wi-Max can be used by a supermarket chain in Colombo to transmit daily transaction details to the head office without using wires.

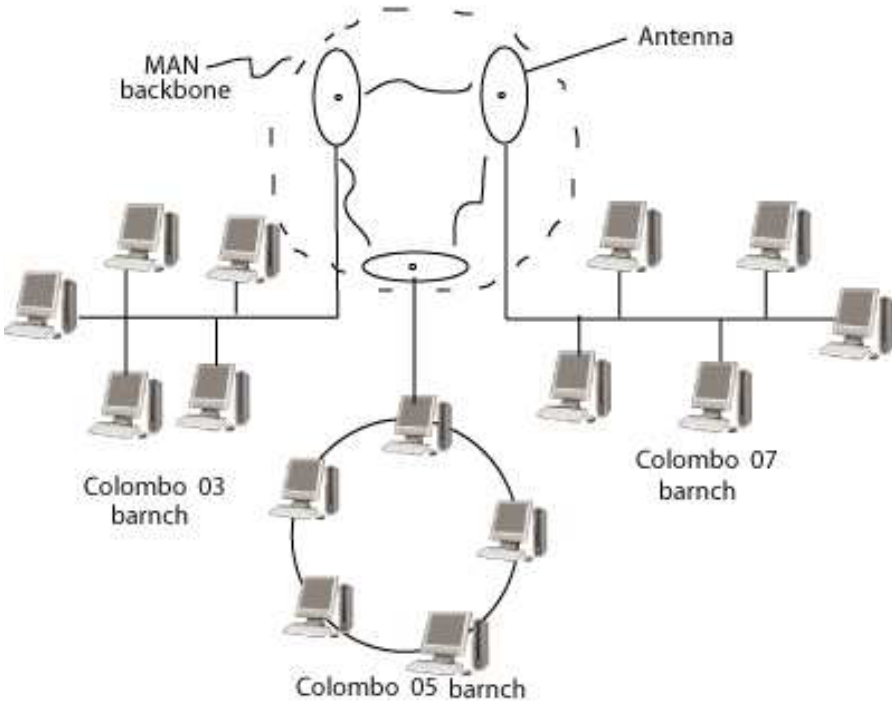


Figure 9.33: Wi-Max

9.5.6 Bluetooth

Bluetooth is a wireless standard which describes how devices like computers (figure 9.34), cellular phones and PDAs can be linked within a short range. Bluetooth uses radio signals to transmit data. For example you can connect a Bluetooth enabled digital diary to a Bluetooth enabled computer to backup your notes at the end of the day.

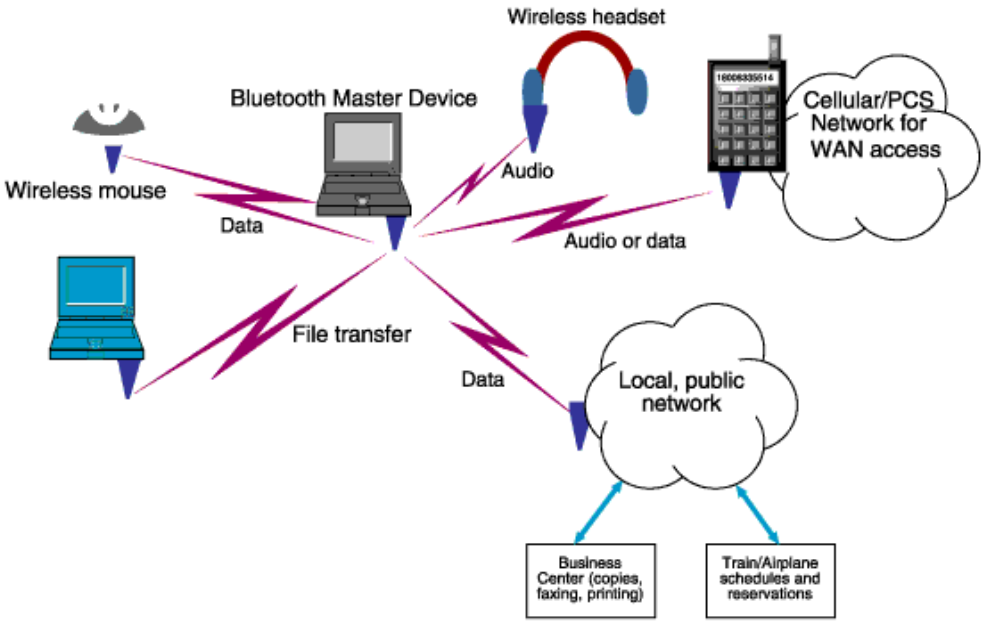


Figure 9.34: Bluetooth

Figure 9.35: Bluetooth Symbol